Selective application of sartorius muscle flaps and aggressive staged surgical debridement can influence long-term outcomes of complex prosthetic graft infections

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Background: **The complexity of variables associated with vascular surgical site infections (VSSI) often contribute adversely to reinfection, limb salvage, and mortality rates. This report details our experience with the selective use of a sartorius muscle flaps (SMF) as part of an overall treatment strategy focused on staged surgical debridement (SSD) to control prosthetic graft bed infection prior to a graft preservation or revision plan.**

Methods: **From our vascular registry, we identified 422 VSSI of which 89 (21%) had SMF for 24 aorto-bifemoral (ABF), 19 extra-anatomic bypasses (EAB), 34 infrainguinal bypasses, and 12 combined inflow/outflow reconstructions. All 86 patients had Szilagyi grade III prosthetic (Dacron-36, polytetrafluoroethylene [PTFE]-50) graft infections. The treatment algorithm included: SSD, culture-directed parenteral antibiotics, graft preservation (n = 3), or reconstruction (graft excision/EAB, n = 4; rifampin-bonded PTFE, n = 22; autologous conduit, n = 57) based on microbiology and consideration for SMF for extensive soft tissue defects (n = 43) or nonsterilized graft beds (n = 40). Analysis of microbiology, recurrent infection, vascular reconstruction, limb salvage, and mortality was completed over a mean follow-up of 52 months (range: 12 to 132 months).**

Results: **Thirty-day mortality was 2% with two aortic graft infections dying from sepsis. Survival by life table analysis at 1, 3, and 5 years was 94%, 92%, and 90%, respectively. Wound isolates were most commonly gram positive organisms (n = 58, 65%), with gram negative isolates and mixed infections accounting for 19% and 10%, respectively. A single recurrent groin infection was documented at 30 days. Freedom from recurrent infection (n = 6) at 1 and 5 years was 98% and 92% by life tables. Methicillen-resistant *Staphylococcus aureus* (MRSA) was involved for 50% of reinfections. No amputations were attributable to uncontrolled VSSI and graft patency was 100% in surveillance monitored patients.**

Conclusion: **These results suggest that selective utilization of SMF as part of SSD treatment plan in an attempt to achieve graft bed sterilization can effectively control the complex infectious process allowing for potentially improved outcomes for in situ or preservation graft salvage techniques. Lifelong graft surveillance is recommended. (J Vasc Surg 2007;46: 71-8.)**

Vascular surgical site infections (VSSI) threaten not only graft patency, but often adversely influence both limb salvage and mortality rates. Historically, these unfavorable outcomes have been associated with the morbidity of extensive graft removals and complex reconstructions in groups of patients who typically have a surplus of other medical comorbidities. Mortality rates among series reporting these infections ranging from 9% to 58% have been documented with limb loss rates reported as high as 79%.[1-5] Because each VSSI is unique to patient's degree of existing arterial occlusive disease including previous vascular procedures, it remains difficult to adopt recommendations based solely on the type of vascular bypass or microbiology of the wound. Likewise, examination of the utility of surgical adjuncts for treating VSSI such as rotational muscle flaps are limited by small series cohorts with variable vascular reconstructions and poor long-term follow-up.

Clinical experience has allowed some authors who treat large numbers of these patients to investigate a variety of factors and adjuncts that may provide improved outcomes among this complicated group of patients.[6-8] For some time now, our tertiary University vascular practice has addressed the issue of VSSI by focusing on identification of causative pathogen and attempting to achieve wound sterilization prior to definitive graft salvage or reconstruction. To this end, we have investigated the use of a variety of surgical adjuncts including staged surgical debridement, antibiotic impregnated beads, parenteral antibiotics, and use of muscle flap coverage in the treatment of VSSIs. This report was developed to better define the actual incidence of Sartorius muscle flap (SMF) required for complicated wound coverage and determine the efficacy of SMF as part of a wound sterilization treatment plan for addressing VSSIs.

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Competition of interest: none.

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Table I. Initial vascular procedures and occluded grafts associated with VSSI

Bypass	*Material*	*N = 86*	*Occlusions (n = 9)*
Aorto-bifemoral	Dacron	21	3†
(n = 24)	PTFE	3	1†
Extra-anatomic	Dacron	4	1
(n = 19)	PTFE	15	
Infrainguinal	Dacron	2	1
(n = 31)	PTFE	29	2
Combined*	Dacron	9	1
(n = 12)	PTFE	3	

PTFE, Polytetrafluoroethylene; *VSSI*, vascular surgical site infections.
*Combined: both inflow and outflow prosthetic reconstructions were present in groin at time of infection.
†Occluded graft limbs.

Table II. Atherosclerotic risk factors and patient characteristics

Coronary artery disease	59 (69%)
Hypertension	75 (87%)
Ipsilateral vascular bypass	19 (22%)
Contralateral vascular bypass	12 (14%)
Contralateral major amputation	3 (3%)
Current smoker	30 (35%)
Tobacco use history	25 (29%)
Diabetes	32 (37%)
COPD*	10 (12%)
ESRD+	2 (2%)

COPD, oxygen dependent and/or steroid dependent; *ESRD*, dialysis dependent.

PATIENTS AND METHODS

Patients. A retrospective review of our vascular registry identified 442 prosthetic VSSI treated over a 13-year period (1994 to 2006). Of this group, 353 VSSIs did not have SMF utilized as part of their treatment plan or had combined intracavitary and extracavitary graft infections and were excluded from detailed analysis. The remaining 89 VSSIs involved 86 patients (47 male, 39 female) who presented with isolated grade III Szilagyi extracavitary inguinal prosthetic graft infections. Three patients had bilateral groin infections associated with one aorto-bifemoral and two femoral-femoral bypass grafts. Initial revascularization procedures included: 24 aorto-bifemoral (ABF), 19 extra-anatomic bypasses (EAB), 31 infrainguinal bypasses, and 12 combined inflow/outflow reconstructions. Dacron grafts (n = 36) were predominately used for ABF and combined reconstructions while and polytetrafluoroethylene (PTFE) (n = 50) composed the majority of EAB or infrainguinal reconstructions (Table I). Atherosclerotic risk stratification for the group is listed in Table II. Within the cohort there were nine (10%) early (<4 months), which presented 6 to 28 days after the initial vascular procedure. The time range for late appearing infections was more difficult to define as the majority of patients were tertiary referrals with incomplete medical records. Typically, patients presented with indolent symptoms as summarized in Table III. However, four patients presented with hemodynamic instability, two with systemic inflammatory response syndrome (SIRS) and two with para-anastomotic hemorrhage.

Table III. Clinical findings and at presentation

Signs/Symptoms	*N = 89 (%)*
Sinus tract	30 (34%)
Cellulitis	25 (28%)
Perigraft fluid collection	24 (27%)
Psuedoaneurysm	10 (11%)
Systemic sepsis	5 (6%)
Bleeding psuedoaneurysm	2 (2%)
Fever/malaise	2 (2%)
Septic emboli	1 (1%)
Patent grafts	80 (90%)
Occluded grafts	9 (10%)

Methods. Our group has previously described our selective algorithm for management of intracavitary and extracavitary graft infections.[6,10] All EAB and ABF infections completed CT imaging to exclude intracavitary or axillary limb involvement, but 19 infrainguinal bypasses did not have a CT scan as part of their initial evaluation because the VSSI was not associated with a previous inflow procedure, prosthetic infection, or showed no signs of distal autologous bypass involvement. The extent of graft involvement in this group was then determined at the time of surgery based on graft incorporation and soft tissue findings. All VSSIs received broad-spectrum parenteral antibiotics including coverage for Methicillen-resistant *Staphylococcus* (MRSA) at admission. Intravenous antibiotic therapy was adjusted according to culture and sensitivity reports and in general parenteral antibiotics were continued 6 weeks after the final operation. Lifelong antibiotic suppression was not used in this group. We reserve use of lifetime antibiotic suppression for patients with *Clostridium* species, or in individuals deemed to ill to undergo surgical management.

Beginning in 2001, one author (D.F.B.) began using antibiotic-loaded polymethylmethacrylate beads as an adjunct in the treatment of extracavitary prosthetic graft infections. In this series, 12 patients had antibiotic beads placed as part of their individualized treatment plan. When antibiotic beads were placed during staged debridement they were removed at the time of documented wound sterilization or by postoperative day 7 of the patient's last procedure

Staged surgical debridement. Initial surgical debridement took place at a mean interval of 2.3 days (range 1 to 5 days) and included excision of all grossly infected tissue and perigraft tissue was swabbed for gram stain and tissue cultures were also obtained. Routine graft bed pulse lavage with Clorpactin (bleach) solution (4 gm/LNS) and washout with "Brown Volcano" (1:1:1 Betadine (Purdue Pharma, Stamford, Conn), hydrogen peroxide, sterile normal saline irrigation) was performed at each debridement. The number of operations per patient varied (mean 2.6/

patient; range 2 to 6) and were based on the wound bed's clinical response to therapy and culture results. If additional debridement was anticipated then only the skin and deep dermal tissue was approximated if possible to prevent desiccation of the graft bed tissues. Multilayered wound closures and vascular reconstructions utilizing graft preservation, autologous tissue, or rifampin-bonded prosthetic graft strategies were performed if the last culture revealed no bacterial growth (aka: "wound sterilization"). For graft beds with residual bacterial counts, but demonstrating a lack of ongoing virulence as defined by an absence of clinical signs of infection including leukocytosis, drainage, necrotic tissue, or inflammation; final revascularization and wound closure was addressed individually based on microbiology, revascularization history, available bypass conduit, and patient comorbidities. In general, bacterial counts $<10^2$ colony forming units in wounds demonstrating clinical progress was desirable before the final wound debridement/revascularization.

Muscle flap construction. There were three basic indications for SMF. Wounds with extensive soft tissue defects (n = 43, 48 %) received a flap procedure regardless of wound microbiology. In this group, the muscle flap was deemed necessary to provide a foundation for soft tissue coverage of the femoral vasculature. Persistent postoperative lymphoceles occurred in six VSSIs and were successfully treated with SMF. The remaining SMF (n = 40, 45%) involved wounds with late appearing infections that documented negative cultures after staged surgical debridement (SSD) (n = 11) or had initially virulent infections that improved clinically after SSD but had persistently positive tissue cultures (n = 29) prior to SMF.

Application of SMF occurred at two distinct intervals. Early flaps were placed in nine, four early (<4 months) and five late VSSIs, at the time of first debridement in the setting of gross wound bed contamination. Four of these early SMF were placed by the referring surgeon while the other five had complex soft tissue wounds with a clinical picture of severe native arterial and anastomotic inflammation, which required revascularization at time of the first debridement. The remaining 80 patients had delayed application of SMF (range 4 to 22 days; mean 9 days) with the flap being placed at the time of documented wound sterilization or at the final revascularization when the graft bed was free of gross signs of infection.

All four of the SMF placed at outside facilities had to be taken down in order to provide additional soft tissue debridement in an effort to clear the perigraft infection. None of these four flaps were viable for repeat application and alternative muscle flaps, (two rectus femoris and two gracilis) were used at the time of final wound closure. From the remaining five early flaps, two developed some degree of flap necrosis and failed during the staged treatment phase. One of these wounds eventually had graft excision and EAB with autologous tissue and did not require muscle flap coverage. The remaining had a rectus muscle flap placed. All the late SMFs were deemed viable with no history of wound complications at 30 days, and no flap necrosis was identified at any procedure done for reinfected wounds during the follow-up period.

Table IV. Graft bed microbiology from 89 vascular surgical site infections

Microorganisms	*Initial isolates (n = 89)*	*Recurrent infections (n = 6)*
Gram +	58 (65 %)	
Staphylococcus species	49	
S aureus	22	
S epidermidis	13	1
Methicillin-resistant	14	3
Streptococcus	2	
Enterococcus	6	
Peptococcus	1	
Gram −	17 (19 %)	
Pseudomonas aeruginosa	12	
Klebsiella pneumonia	2	1
Escherichia coli	2	
Serratia marcescens	1	
Mixed gram +/−	9 (10%)	
Candida species	2 (2%)	
No growth	3 (3%)	1

RESULTS

Surgical site microbiology. Wound isolates were most commonly gram positive organisms (n = 58, 65%) with gram negative isolates and mixed infections accounting for 19% and 10%, respectively. Single organism recovery was most common (n = 77, 87%) with nine VSSI infections yielding two or more pathogens. Two graft beds had *Candida* species recovered and no growth was present in three VSSIs. Graft bed microbiology is summarized in Table IV.

According to chart review wound sterilization, defined as negative cultures for the surgical site was documented in 52% (n = 46) VSSIs. Graft beds with negative cultures at final revascularization included six (13%) wounds with persistent lymphoceles, 29 (63%) wounds with complex soft tissue defects, and 11 (24%) wounds completing SSD. Fifteen of these wounds with mixed pathogens cleared two or more pathogens. Of the nine early graft infections, seven achieved sterilization prior to revascularization. Thirty-nine of 80 (49%) of late appearing VSSI attained sterilization.

The remaining 43 (48%) VSSIs improved clinically but did not have negative cultures at the time of their final operative procedure. Seven of these wounds with mixed pathogens cleared one or more organisms, but not all. An additional five developed nosocomial isolates during the course of therapy (three MRSA, one *Pseudomonas*, one *Candida* species). Fourteen nonsterile wounds were associated with complex soft tissue defects and single isolates at the time of SMF application. The remaining 17 nonsterile wounds had reduced colony counts and demonstrated clinical improvement after SSD and received simultaneous revascularization with SMF as their final procedure.

Recurrent infection. Recurrent VSSIs occurred in two of three (66%) patients initially treated with graft

Table V. Life table analysis freedom from recurrent infection

Inter-val (mo)	*No. VSSI at risk*	*No. of deaths*	*No. lost to follow-up*	*Recurrent infection*	*Interval recurrent infection*	*Cumulative recurrent infection*	*SE (%)*
1	89	2	0	1	98.9	98.9	0
3	87	0	0	0	100	98.9	1.1
6	87	1	0	0	100	98.9	1.1
12	86	2	0	1	98.8	97.7	1.5
18	83	0	1	1	98.8	96.5	1.8
24	82	0	1	1	98.8	95.3	2.4
30	78	1	2	0	100	95.3	2.4
36	75	1	5	1	98.6	93.9	2.7
42	69	0	4	0	100	93.9	2.8
48	63	0	7	1	98.3	92.2	3.3
54	56	0	1	0	98.3	92.2	3.5
60	53	1	10	0	98.3	92.2	3.6
66	42	1	8	0	98.3	92.2	4.0
72	33	0	5	0	98.3	92.2	4.5

VSSI, Vascular surgical site infections; *SE*, standard error.

preservation and three of 22 (14%) of patients receiving rifampin-bonded in situ graft replacement.

One early recurrent infection (<30 days from SMF application) developed in a patient with history of multiple inflow procedures and was found to have an isolated segment of retained Dacron graft from a previous bypass procedure. This graft segment was removed, and the patient was treated according to culture results and the SMF/rifampin bonded PTFE interposition limb was salvaged. Beyond 30 days, recurrent infection occurred in an additional five patients at a mean interval of 23 months (range 1 to 47 months). Reinfection rates by life table estimate were 2.3 % and 8 % at 1 and 5 years, respectively. Table IV lists recurrent isolates and Table V summarizes freedom from infection by life table. MRSA accounted for three recurrent infections with a biform *Staphylococcus* and *Candida* species infections accounting for two of the recurrences. The single gram-negative recurrence (*K pneumoniae*) occurred in a graft bed that initially had cleared a gram positive infection. Among the late recurrences (>30 days) there were two graft preservations and three rifampin-bonded limb replacements. One late recurrence was treated with graft excision and EAB, while the other four had graft excision with autologous reconstruction in three and rifampin-bonded limb replacement in one.

Vascular reconstruction. Four patients presented with acute limb ischemia and early graft infection (one ABF, one iliac artery occlusion, one femoral artery occlusion, one femoral-infrageniculate bypasses) and required emergent arterial revascularization at the time of their first debridement. An additional five patients with one early and four late VSSIs developed limb ischemia prior to wound sterilization or clinical improvement of the graft bed, (two ABF, two EAB, one femoral-infrageniculate bypass) necessitating urgent revascularization. Among this group of nine requiring emergent or urgent limb salvage, reconstructions included two thrombectomies (one with a combined iliac stent), three rifampin-bonded PTFE (one that later developed a late MRSA reinfection and one of which was later replaced with autologous tissue due to ongoing infectious concerns), and four graft excisions with autologous reconstructions. There were two patients who had prolonged ischemia prior to transfer that required below knee amputation despite successful inflow revascularization.

Table VI. Initial and final vascular reconstructions

Initial VSSI	*Final vascular reconstruction*	
Aorto-bifemoral (n = 24)	Total graft excision and EAB	4
	Partial graft-limb excision and rifampin-PTFE	13
	Partial graft-limb excision and autologous bypass	7
Extra-anatomic (n = 19)	Graft preservation	1
	Total graft excision and autologous bypass	7
	Partial graft excision and rifampin-PTFE	3
	Partial graft excision and autologous bypass	8
Infrainguinal (n = 31)	Graft preservation	2
	Total graft excision and PTFE bypass	2
	Total graft excision and autologous bypass	27
Combined* (n = 12)	Partial graft excision and rifampin-PTFE bypass	4
	Partial graft excision and autologous bypass	8

VSSI, Vascular surgical site infections; *PTFE*, polytetrafluoroethylene; *EAB*, extra-anatomic bypasses.
*Combined: both inflow and outflow prosthetic reconstructions were present in groin at time of infection.

The remaining VSSIs, all presented with a history of peripheral artery disease and chronic limb ischemia. Table VI contrasts the initial and final vascular reconstructions. Two patients required femoral-distal bypass procedure for progression of infrageniculate atherosclerotic disease during the follow-up period on the infected limb side while an additional two patients had vein graft revisions (one balloon angioplasty, one vein patch) during duplex surveil-

Table VII. Life table analysis survival

Interval (mo)	*No.VSSI at risk*	*No. of deaths*	*No. lost to follow-up*	*Interval survival (%)*	*Cumulative survival (%)*	*SE (%)*
1	89	2	0	97.7	97.7	0
3	87	0	0	100.0	97.7	1.5
6	87	1	0	98.8	96.5	1.8
12	86	2	0	97.7	94.2	2.5
18	83	0	1	100	94.2	2.5
24	82	0	1	100	94.2	2.5
30	78	1	2	98.7	92.9	2.8
36	75	1	5	98.6	91.5	3.0
42	69	0	4	100	91.5	3.1
48	63	0	7	100	91.5	3.3
54	56	0	1	100	91.5	3.5
60	53	1	10	98.2	89.7	3.9
66	42	1	8	97.4	87.0	4.8
72	33	0	5	97.4	87.0	5.5

VSSI, Vascular surgical site infections; *SE*, standard error.

lance over their follow-up. Excluding the two initial below knee amputations, the overall limb salvage rate has been 100% for those not lost to follow-up with graft patency rate of 100% for those who remained in duplex surveillance.

Disposition. All surviving patients completed wound closure or wound coverage with skin grafting at the time discharge from the hospital. Mean hospital length of stay was 17 days (range 6 to 112 days). Two patients presenting with systemic inflammatory response syndrome (SIRS) and aortic limb graft infection died within 30 days due to sepsis and multisystem organ failure. According to medical records, telephone contact, or Social Security Death Index, seven additional deaths occurred over the follow-up period (three cardiac two respiratory, one cancer, one unknown) with three of these occurring in the first year of follow-up. One of these was a respiratory death in the hospital at 54 days. Life table analysis is shown in Table VII reports one and 5-year survival of 98% and 90%, respectively.

DISCUSSION

The long-established practice of total graft excision and extra-anatomic revascularization has been challenged in an effort to improve clinical outcomes in some subgroups of patients. Certainly, among some infections such as aortoenteric erosions few other options are possible, while, the virulent nature of gram negatives and antibiotic resistant pathogens have been associated with generally poorer outcomes.[9,17] The often unpleasant consequences of total graft excision and complex revascularization has prompted surgical groups to investigate alternative treatment strategies such as in situ reconstructions and graft preservation.[6-9]

In considering alternative revascularizations, we have embraced the concept of "wound sterilization", which has matured over the last 5 years to become what we consider the core component in the treatment of VSSI. Wound sterilization is not a new innovation as other orthopedic and reconstruction specialists have relied on a similar strategy to treat complex prosthetic implant infections for some time now. The benefit of "wound sterilization" is based on the premise that wounds with minimal bacterial colonization will have less healing setbacks therefore improve the clinical success rates. Application of this clinical pathway (Fig) has resulted in improved wound sterilization rates from just less than 50% to 87% in a recent consecutive VSSI series.[18] A query of our vascular database during the same time period identified 234 grade II and III inguinal VSSIs that did not have SMF as part of their treatment plan. While the diversity of presentation and length of follow-up make for difficult direct statistical comparison, the overall reinfection rate for this group was 9% (22/234) compared with a 7% reinfection rate in VSSI treated with adjunctive SMF suggesting that SMF alone may not provide any significant protective benefit against reinfection.

In the current, series we are able to clear a variety of wound infections, including the traditionally more stubborn gram negative, polymicrobial, and antibiotic-resistant pathogens. Negative wound cultures were often achieved before the application of SMF suggesting that SMF is not required for wound sterilization. Considering the reinfections seen in this series, five of six were associated with wounds that did not achieve negative cultures and 50% involved antibiotic-resistant pathogens in the setting of nonautologous reconstructions. Over the last 6 years, we have noted a distinct trend towards an increased incidence of infectious recurrences involving resistant pathogens especially among graft preservation or prosthetic in situ reconstructions.[6,10,18]

As a regional referral center, we are often unable to control the presentation and previous vascular history of the patients who present to our facility with VSSI making randomization into treatment arms impractical. Likewise, our catchment area is large making regular office evaluations difficult and infrequent as evidenced by more than 50% of SMFs unavailable for evaluation at 6 years. However, the standard error of the mean (SEM) remains $<10\%$ during that time period. Nonetheless, as a subgroup of VSSIs, this retrospective clinical review is exposed to the traditional statistical weaknesses known to such repots.

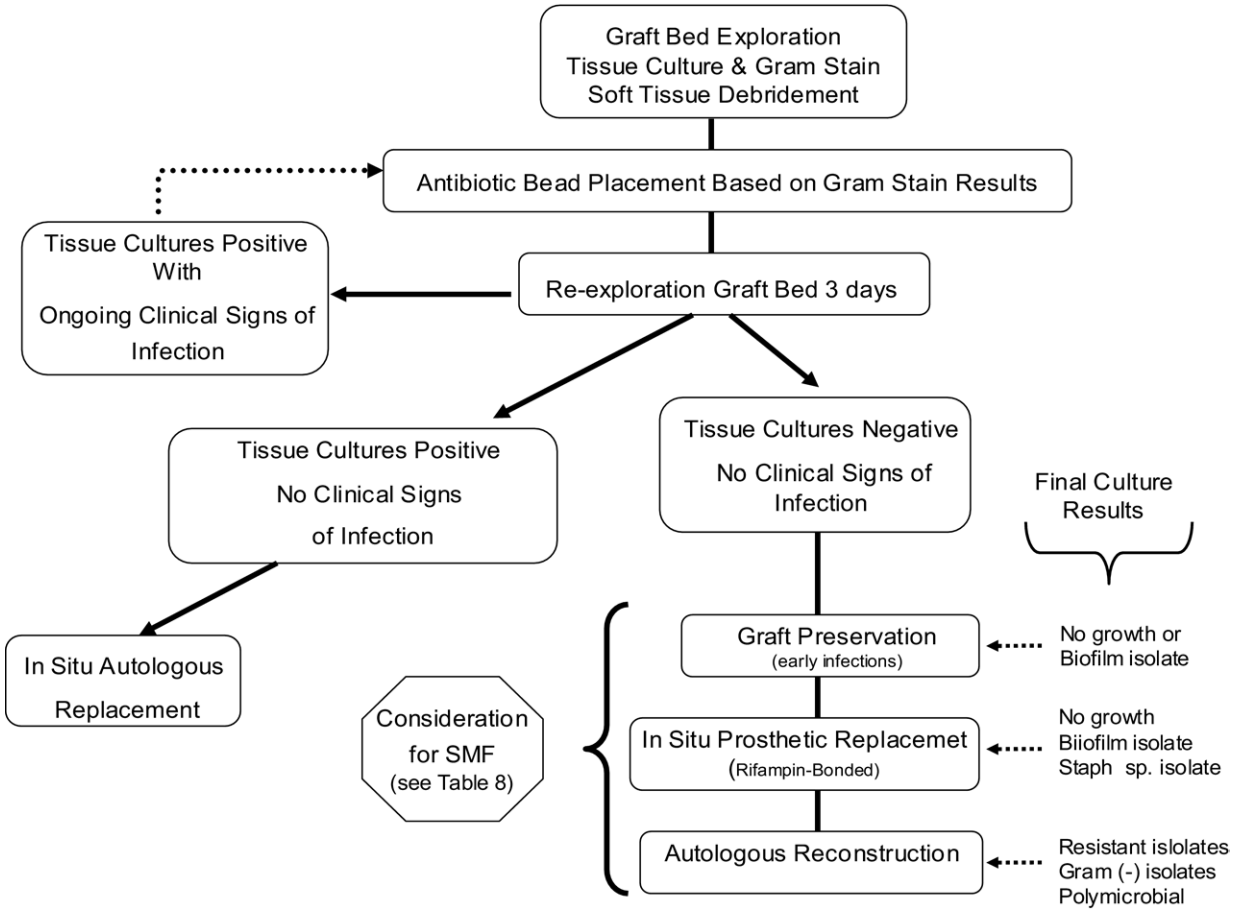

Fig. Patient-specific treatment algorithm for VSSI based graft bed microbiology and clinical improvement of the wound.

What then is the utility of a rotational muscle flap beyond soft tissue coverage? Application of a muscle flap to provide closure of a complex wound or coverage of a vascular graft bed is not a novel idea.[4,11,12] Surprisingly, contemporary reports on muscle flap coverage of prosthetic VSSI in general contain small cohorts of patients who are offered an assortment of flap procedures applied to a variety of vascular beds and much of this work has not been verified by vascular surgeons who routinely treat VSSI.

Some authors have advocated early flap application but the optimum timing of flap construction is not well defined.[13,14] Treiman et al and others have suggested that routine rotational or free flap muscle coverage should be utilized early in the treatment plan in order to reduce the morbidity associated with VSSIs.[15] In this series, early application of SMF prior to local control of infection risked loss of the flap. Although there were much fewer early graft applications, in each instance where graft bed infection was not controlled, the SMF was not fit for reapplication or was a risk for failure due to the ongoing infectious process necessitating removal of portions of the flap at each serial debridement. Once released from its origin, the muscle remodels in both size and function. The motor function of the muscle has now been replaced with a designation as deep tissue coverage improving both leukocyte function and oxygen tension to the wound thus impairing bacterial replication.[16] This role of the SMF as wound protector and healer becomes disrupted at each serial debridement as portions of the muscle become devitalized and do not recover as the muscle naturally atrophies while failure to clear or reduce the graft bed of bacterial contamination risks reinfection and limb loss. Timing of muscle flap application then becomes as critical as maintaining proper blood supply to the flap in terms of technical success if we expect the flap to not only cover the wound but aid in bacterial eradication.

The SMF has been criticized as a poor choice of flap because it is often associated with the infected graft bed.[5] In general, the majority of VSSI infections are indolent and perigraft in location. They do not routinely involve extensive fasciaitis or myonecrosis at presentation. The strategy of staged graft bed debridements to remove all grossly infected soft tissue, which primarily includes only skin and subcutaneous tissue, allows for optimum control of local

Table VIII. Criteria for individualized revascularization and application sartorius muscle flap based on clinical findings and final graft bed cultures

	Routine application SMF		*Selective application SMF*				
	Complex soft tissue defect	*Persistent lymphocele*	*Wound sterilization*	*Biofilm isolate*	*Antibiotic-resistant isolate*	*Gram (-) isolate*	*Mixed gram (+/-) isolate*
Graft preservation (early infection)	yes	Yes	yes	no*	yes	no*	no*
Rifampin-bonded in situ PTFE	yes	Yes	no	no†	no*	no*	no*
Autologous revascularization	yes	Yes	no	no	no	no†	no†

*Not a recommended reconstruction option according to graft bed microbiology.
†Consideration for SMF in the setting of virulent infection.

infection. This leaves a wound bed that in some cases will be culture negative or at a minimum will have a significantly reduced bacterial count. This important alteration in the wound environment enhances the protective effects of the rotated muscle flap. Because of the relative ease in completing a rotational SMF, our group has found it generally unnecessary to use alternative rotational muscle or free muscle flaps. In this series, we used two rotational gracilis and three rotational rectus femoris flaps to treat failed early applied SMFs.

As we have sought to clinically validate this clinical pathway, several distinct trends in our successes and failures have become evident. First, we now only consider graft preservation for only early VSSIs. We have regularly noted recurrent infections when using this technique with wounds harboring late infections even when including SMF as an adjunct to graft preservation. Second, the addition of antibiotic-loaded beads to SSD has resulted increased wound sterilization rates. Although the application of antibiotic beads requires additional long- term study, our most recent clinical review confers a relative safety to the techniques and documents improved wound sterilization compared with previous infections we have treated without beads.[18] And finally, proper timing and selective application of SMF results in a viable rotational flap that will facilitate improved wound healing rates with low procedural morbidity/mortality.

CONCLUSION

Because the extent of clinically significant vascular disease, history of vascular reconstructions, and medical comorbidities are often diverse among vascular patients, our vascular group has emphasized an individualized treatment algorithm that treats VSSI by utilizing graft preservation, in situ limb replacement as well as graft excision methods (Table VIII). By attempting to achieve a sterilized graft bed prior to a graft preservation or revascularization, we believe that we give both the traditional and more contemporary treatment methods the best chance for favorable outcomes. Clearly, rotational muscle flaps are not required for every VSSI, but they should be considered beyond the simple principle of providing soft tissue coverage for large wounds or persistent lymphoceles. This is especially true when a in situ prosthetic or graft preservation strategy is being employed especially in the setting of more virulent pathogens such as polymicrobial, gram negative, or antibiotic-resistant VSSIs. Knowledge of the technical points associated with the procedure as well as proper timing for application ensures graft viability. Lifelong graft surveillance should be compulsory regardless of the final revascularization plan among individuals at risk for infection.

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